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THE OTOPHONE: ITS HISTORY, WITH A DESCRIPTION OF ITS VARIOUS FORMS, ITS USE BY THE DEAF, ITS VALUE AS AN AID TO RESTORATION OF HEARING, AND IN THE INSTRUCTION AND DEVELOPMENT OF HEARING AND ARTICULATION IN THE DEAF-DUMB.

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By J. A. MALONEY, WASHINGTON, D. C.

SOME years since, while experimenting in the field of acoustics, the thought occurred to me that a new field might be opened for relieving the deaf by constructing the agent of relief to meet the requirements of defective audition in each case as nearly as possible. To that end, after study of the anatomy and physiology of the ear, together with such light as the limited literature upon "Physiological Acoustics" afforded, I commenced my labors in "Aural Mechanics," with a mode of procedure as follows:

1st. To develop instruments as far as I could to meet the various phases of defective audition;

2d. To construct the instruments to give satisfactory results without entering the auditory canal;

3d. To use artificial drums or membranes to guard against impact of air upon the *membrana tympani*, and prevent reverberation or disagreeable resonance so common in all the old forms of instruments.

I decided that a scientific instrument should possess these three essential qualities: It should be large enough to be of practical value; it should augment sounds; but with such augmentation the timbre or quality of sound should be preserved.

The augmentation and clearness must be to the extent

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that the person will hear every word spoken, instead of a word here and there, as heretofore, which involves a severe mental strain to construct the incomplete sentence.

We are all aware that the *membrana tympani*, unlike other stretched membranes, responds to all vibratory motions within a certain limit, whether they are in the form of noise or of composite tones, transmitting, through the intermediate agencies of the middle and inner ear, to the nerve of hearing auditory sensations. Could a stretched membrane be arranged that closely imitated in function the one given to man?

After experimenting twelve months I adopted the form of membrane which is here presented. See figs. 1 and 2. The reasons for its adoption came about in this way: In the early stage of my experiments I invariably found a lack of clearness of tone, until one day the thought occurred to me that I could secure uniformity of tension by clamping the membrane between two rings. When this was done I found it a great improvement over all other methods, and consequently adopted it after thorough tests. Even after obtaining good results I could not but feel that there must be some other result produced by the rings than that of maintaining a uniform tension of the membrane. I found that while the membrane was upon the stretcher-frame, with the rings glued upon each side of it, like any other membrane, it would be thrown into sympathetic vibrations by tones corresponding to its fundamental; *but that when cut from the frame*, and dependent for its tension upon the two rings alone, it did not exhibit excessive sympathetic vibrations of its own fundamental, but was very sensitive to composite tone vibrations. Now it has been thought that the last-named feature exhibited by the *membrana tympani* was produced by its union with the auditory ossicles. But may it not be due to two facts? 1st. That the margin is thickened; 2d. That the middle layer, or *substantia propria*, is fixed to a ring of bone.

The instruments are known as Nos. 1, 2, 3, No 1 being used simply to render clear and distinct all sounds to those partially deaf. No 2 is a small instrument, and is fastened

to the auricle by a locking device, kept in place by the *tragus*, *antitragus*, and *concha*.

No. 3 is used by those extremely hard of hearing, and also as a restorative agent by means of exercise through the natural means, *i. e.*, the voice, which at the same time (by reason of clearness of tone) overcomes the sluggishness or dulness of the "percipient tract." This form is intended for use in the education of the deaf-dumb.

The following cases will give results from use of instruments :

Mr. C., aged sixty-five, while in Washington called upon me and said he had always had difficulty in hearing, but more so of late years. Upon examination I found malformation of auricle, the space between *helix* and *tragus* being very narrow and the *concha* very shallow. The person could hear an ordinary tone

Fig. 1.

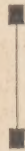


Fig. 2.



about four feet away. Upon placing one of No. 2 in each ear (being made to suit the shape of each ear), he was able to hear the same tone at a distance of twenty-five feet.

Mr. M., aged forty-seven, could not hear at a distance of three feet ordinary conversational tones. I found malformation of auricle. Upon making and fitting a pair of No. 2 arranged to suit his tone defect, he could hear distinctly a conversational tone a distance of thirty feet.

Mr. H. H. F., of Philadelphia, aged fifty (sent by Dr. S. Weir Mitchell), I met at the office Dr. Chas. H. Burnett in Philadelphia. He was very despondent, and I found that an ordinary tone spoken at the meatus by Dr. Burnett could not be heard. Upon applying a No. 3 otophone he heard every thing said in a very low voice, and without any difficulty could distinguish between B, P, and T, much to the surprise and joy of the person, who exclaimed: "Why, with this, every sound comes to me clearly and naturally! Heretofore I have had to go to the words without much success."

Mrs. G. P., aged sixty-five, could hear loud tone close to meatus. With instrument could hear conversational tones clearly and with relief to members of her family, who had difficulty in making themselves heard with old forms of instruments.

Mr. M., eighty-five years of age. The following is from the physician who ordered an instrument: "His eighty-five years sit more lightly upon his aged body. In fact it has opened up a new world to him."

Mrs. McC., aged fifty, had used all kinds of instruments prior to use of No. 3. Her physician reports it a comfort to her family and improvement to patient by its use.

Mr. G. W., aged fifty-five, extremely hard of hearing for twenty years, could hear a loud tone when spoken close to meatus. Finds the instrument a great assistance, and in thirty days could hear a low tone eighteen inches from meatus without instrument.

Dr. J. H. B., aged thirty-two, presented himself for test at the meeting of the Medical Society of the District of Columbia, May 4, 1887. Could not hear a loud tone close to meatus on right side. With instrument could hear every word spoken in a low tone. Commenced to exercise that side. He is now able to hear a conversational tone at a distance of fifteen feet without instrument.

C. H. M., aged forty-five. An engineer retired from U. S. Navy by reason of deafness. Had been using No. 3 Otophone four weeks when he wrote: "It is helping me."

The following will show results upon the deaf-dumb, produced at the Pennsylvania Institution for the Deaf and Dumb (Philadelphia) at the suggestion and under the supervision of Dr. C. H. Burnett.

a.—Congenital Deafness.

(1.) Ida B., aged twenty-one years. Has a deaf brother. She cannot read the lips. Has been eight years in the institution. The vowels were repeated to her three times in succession through the otophone, first at the right ear. She noticed a difference in the sounds, but could not indicate which vowels were being repeated to her. The left ear was then tested, and she indicated O twice, correctly, and noticed when the ear-piece slipped below the meatus, and so informed us. With this case test-words were

also employed, these being Philadelphia, Mississippi, Burlington, written and then pointed out to the pupil during their repetition. She indicated Mississippi and Philadelphia, and then Mississippi, again and again, when it recurred in the testing, but failed to get "Burlington."

(2.) Emma R. K., fifteen years old ; has deaf parents and a deaf maternal uncle ; also a brother a deaf-mute in the Institution. She has been four years in the school. She perceived sound by the otophone, and said, after the vowels were repeated to her three times, that A and U are different. She indicated correctly A, O, and U, missing, of course, a number between the successful replies.

(3.) John K. (brother of the previous case), sixteen years old ; heard sound in right ear through the tube, but failed to indicate correctly, after the testing by five vowels. Three vowels were then tried, viz., A, E, and O. He said they all sounded alike excepting E, but he indicated correctly O. No results in testing left ear. The word-tests were then employed, as in the previous case. Successfully indicated "Mississippi" and "Burlington." "Missouri" was now added to the word-tests, and "Missouri" was successfully indicated three times in succession. Of course there were numerous misses, but the successful indications were manifestly not guesses.

(4.) James P., seventeen years old ; *parents both mutes, father a congenital mute, the mother such by acquisition. He has also two congenital mute sisters, a deaf uncle, and a deaf aunt.* He perceives the sound of the word, Halloa ! through the otophone, and says it is disagreeable, but does not hurt. The five vowels were first tried in this case, with the left ear. A and O successfully indicated, E mistaken for U and I. The right ear was then tried, and A, I, O, and U were indicated. The word-tests, the four words already employed, were then repeated to him three times, and they were all correctly indicated. So striking was this result that Mr. Crouter, the Superintendent, felt that in one who was supposed never to have heard, it must be successful guessing.

(5.) May S., fifteen years old, sister of case 1. Has been in the Institution four years. Tried three vowels, A, E, and O, three times repeated in the right ear, and pointed out to her at the same time. She pointed out successfully, when repeated, O several times, and A and I mistaken for E. Left ear, A and O a number of times successfully indicated. The word-tests were then employed in the right ear, the four already named being repeated

three times in succession. Then when the pupil was requested to indicate what was repeated, she succeeded in indicating Philadelphia, Mississippi, Burlington, and Missouri, a number of times correctly.

The vowel O, was once understood by her as *boy*. *Boy* was then written and repeated to her, being at the same time pointed out to her, and when given among other test words, it was correctly pointed out by her each time.

b.—Acquired Deafness.

(6.) Mary J. McD., nineteen years old, no deafness in her family. She became deaf at four years of age, after she had learned to talk; but has since lost the ability to talk. With the right ear does not distinguish the vowels. In the left ear she says they "sound loud." The vowels were then repeated and pointed out to her three times, as already described. She got O, several times, then A, I, O. Word-tests, *papa*, *mama*, *baby*, *boy*, were then employed, and she successfully indicated *mama*, *baby*, and *papa*.

(7.) Annie S., seventeen years old, became deaf at four years of age. No deafness in her family. She once spoke German, her mother-tongue. O was perceived correctly by the left ear; she "feels it a little in the right ear."

(8.) Sarah E., nineteen years old, became deaf at three years of age. Has no deaf relations. The vowels A, I, and O, were first used as tests. She indicated successfully, O, A, and I, repeatedly by the left ear. In the right ear, I and O were said to sound alike—O was heard best, I next, and A, third.

(9.) Geo. L. H., aged seventeen years, became deaf at the age of three and a half years, after he had learned to talk, but since has lost the ability. Has no deaf relations. He says he feels the sound in his left ear. First tested with an A, I, and O; all successfully indicated. Then tested by means of A, B, and O. He successfully indicated B, A several times.

(10.) George G., eighteen years old, became deaf from measles at four years of age, after he had learned to talk. Perceives sound "just a little" through the instrument.

(11.) Harvey De L., nineteen years old, became deaf at the age of five years, from spotted fever. He perceives a little through the right ear.

(12.) Oliver E., eighteen years old, became deaf from a catarh at six years of age. Can speak. In the right ear "feels"

the vowels a little. Indicated correctly three times A and I. No word-tests, like those previously used, were employed, as the results with the vowels, in the cases of acquired deafness, were not as good as in the so-called congenital cases.

c.—Semi-mutes.

Tests were made in the cases of two boys with acquired deafness and instructed like mutes; but still able to talk, and to hear some.

(13.) Benj. G., seventeen years old, became very deaf at nine years of age, probably from a purulent process, as indicated by the membrana tympani. This boy heard every thing said to him through the otophone, and returned intelligent articulate answers to all the questions.

(14.) Thos. O'B., aged eighteen years; became deaf at the age of four years, from spotted fever. He hears very well by means of the otophone.

The articulation in such cases could, without doubt, be greatly improved by the use of such an instrument, if its employment as a means of instruction could be begun early in life. Also the function of hearing could be better retained and perhaps improved by the normal exercise it would obtain by hearing through the otophone.

The following tests were made at the National Deaf-Mute College, Washington, D. C., under supervision of Dr. F. B. Loring, and in the presence of Dr. Gallaudet and Profs. Gordon, Denison, and Ballard. The tests were made with an otophone No. 3. The following is from the report of Dr. Loring:

The method used was to write five vowels on a piece of paper which was placed in the hands of the person being examined; then the particular vowel spoken through the otophone by Mr. Maloney, was pointed out by Mr. Wight. This was repeated three times in order to impress the different sounds of the letters upon the ear. The pupil being then required to point to the vowel given—two consecutive ones at no time being used. Words were also written in the same way, viz., "Mississippi," "Baltimore," and "New

York." The number of vowels in some cases was, however, reduced to three, as five were found to be too many to be carried in the memory of the deaf and dumb, as it must be borne in mind that names and letters convey no impression to the deaf-mute, and that he is not by any means on the same footing as a "hearing person" (as they themselves express it) who has lost hearing late in life. In other words his ear may recognize distinctly the different sounds as given through the otophone, while his memory entirely unpractised as regards sound may not be able to refer it correctly to the vowel indicated.

The tabulated result of the thirteen cases was as follows :

CLASS I.—*Congenital.*

W. A., age seventeen ; distinguishes five vowels correctly after they have been repeated four times.

Mr. S., age twenty-three ; distinguishes all vowels.

Mr. O., age sixteen ; repeats three vowels ; cannot carry five ; also distinguishes between "Mississippi" and "Baltimore."

L. S., ten years ; no improvement, and complains of pain.

Mr. T., age twenty-four ; can recognize three vowels.

CLASS II.—*Hearing lost between ages of one and five years.*

Mr. H., twenty-one years ; lost hearing from scarlet-fever at five years ; hears all vowels.

Mr. H., nineteen years ; lost hearing at eleven months ; hears and repeats all vowels, also three words.

Miss A. W., fourteen years ; lost hearing from scarlet-fever at three months ; gets A, O, and I.

N. L., aged twenty-three ; lost from brain-fever at two years ; no improvement ; no conduction, either aërial or osseous.

Mr. R., age nineteen ; spinal meningitis at five years ; hears and repeats four vowels out of five, also "Boston" and "Mississippi" ; cannot distinguish between "Baltimore" and "Boston."

CLASS III.—*Semi-mutes.*

Mr. D., forty years ; deaf on one side to such an extent that no sound could be distinguished on the other ; could converse with trumpet ; this condition had existed for over thirty-five years.

With otophone hears conversation easily with worse ear, and with the better one the instrument can be removed for at least four inches from contact with concha.

Case number two in this class is a curious one ; he has been educated as a deaf-mute and uses the sign language entirely, making his replies verbally, speaks naturally, and is an expert lip reader. With the otophone, however, he understands conversation perfectly with either ear.

Mr. H. has a natural voice ; lost his hearing from scarlet-fever at five years ; is now twenty-nine ; hears all the vowels and is doubtless capable of much improvement.

In view of the results obtained (as shown by the foregoing cases) in the appeal to sight, hearing, and memory, I shall conclude by calling attention to the following from a pamphlet by Samuel Sexton, M.D., New York, 1884, "On the Necessity of Providing for the Better Education of Children with Defective Hearing in the Public Schools," pp. 14, 15 :

"The importance of early training for deaf children.—Too much stress can scarcely be laid on the value of results obtainable in this way if early made, since the perceptive power may be much quickened by training in many instances, even where the middle-ear apparatus is defective. It would appear to be on the development of the perceptive tract, rather than on any change in the transmitting mechanism, that mental improvement depends in the very deaf who are taught aurally. The expert himself finds it no easy task to get at the facts in certain cases, especially in young children who have already been instructed as totally deaf, since they soon come to disregard the hearing sense entirely, and it remains to be determined in such cases how much the auditory nerve has deteriorated from disuse. The professed indifference to hearing should never prevent some attempts being made at instruction through the hearing organs, since a surprising amount of hearing may thus be found to exist. How many children one meets with who are backward in learning to talk, but finally, on getting to be three or four years old, gain their speech ! Such chil-

dren would get on much faster in many instances, it is believed, if regarded as partially deaf. While treating such children professionally I have seen beneficial results from the use of conversation-tubes, or the employment of voice at close range. This practice cannot be too early commenced. I have observed good results in children as young as eighteen months. In observing these cases one cannot but be impressed with the importance of normal hearing in the ready acquirement of speech, and that however imperfect the hearing may be, it has its uses in acquiring languages."

This is a very clear presentation by Dr. Sexton of the needs of the deaf and deaf-dumb, in whose behalf he has spent so much time and thought.

Also the following from Dr. C. H. Burnett before the Philadelphia County Medical Society April 27, 1887. (See *Medical News*, May 7th.)

EAR-TRUMPETS.

"There are three reasons, he said, why the deaf should use ear-trumpets :

"1. In order to aid the hearing. 2. To improve the hearing. 3. For the convenience and comfort of those conversing with the very deaf.

"1. The cause of ordinary deafness is, in most cases, a catarrhal thickening of the mucous membrane over the ossicles and the inner surface of the membrana tympani, leading to more or less ankylosis in these parts. Passive motion overcomes in them, to a greater or less extent, the immobility induced by this sclerotic process, as it does elsewhere in the osseous and muscular system. The form of passive motion which acts most naturally on the ossicula auditus and their joints, is sound. If, therefore, sound-waves are concentrated in more than usual quantity or vigor upon the stiffened membrana and the ossicles, as by means of an ear-trumpet, hearing is induced, if the auditory nerve is unimpaired. If the latter is impaired, no form of ear-trumpet will be of use.

"2. Not only does such a form of passive motion give immediate relief to the deafness in most cases, but such a

form of passive motion, acting frequently and systematically upon the ear, prevents further ankylosis in the conductors, and fatty degeneration of the auditory nerve from desuetude. This, of course, tends to a permanent improvement of the hearing, and, in some instances, patients come to hear at last without a trumpet. If such a force were brought to bear early in cases of deafness from ankylosis in the ossicula, the defects in hearing could, in most cases, be arrested, and, to some extent, removed. This form of aid to hearing has its happiest results in very deaf children, in whom the loss of hearing often entails loss of speech, if they have already learned it. If they have not learned to talk, and their deafness depends on catarrhal disease in the middle ear, and not on a lesion of the acoustic nerve, the use of a good ear-trumpet will rescue them from entire deaf-dumbness.

“3. The most useful ear-trumpets yet presented to his notice are those of Mr. Maloney, who exhibits them here to-night. They are not only useful as conductors of sound, succeeding where other forms fail, but they do not fit into the meatus. They are held to the ear, the aural end of the instrument being supplied with a disc, and not a tip for the meatus. This does away with bruising the canal, or exciting furuncles in it, so common in the employment of the forms heretofore in use. They have been devised in a scientific manner, and introduced to the profession on their own merit. The best results, or the most signal ones, have been obtained by the so-called silent instrument. This is simply because it is the most powerful, and hence renders most aid to the very deaf, the only people who are really willing to use any instrument. The smaller instruments are just as good for those not very deaf, and, if used by such patients, would aid in the retention of hearing, and tend to cure their hardness of hearing, as he has shown. But the less-afflicted class seem unwilling to use any form of ear-trumpet. All ear-trumpets of any value must possess some size in order to contain a column of air sufficient to impress the drum. They must be larger than the auricle with which the patient is already supplied. Hence, all invisible appliances, so-called, are self-evidently good for nothing.”

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